JOURNAL OF BALTIC SCIENCE EDUCATION

ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

THE EFFECTS OF SCIENCE CLUB ACTIVITIES ON SECONDARY SCHOOL STUDENTS' CREATIVE SELF-EFFICACY: MEDIATING QUALITY EDUCATION AND MODERATING ICT USAGE

Weimiao Wu,
Kyung Hee Park

Abstract. *Engagement in science club activities at school has been identified as a crucial experience for developing creative self-efficacy while also fostering students' social and emotional growth. The effects of science club activities on students' creative self-efficacy were analyzed using difference verification and structural equation modeling in this study, focusing on a sample of 5,737 Korean secondary school students. Additionally, the study explored the mediating effects of quality teacher and classroom support, which can enhance academic achievement, while concurrently assessing the experience of ICT usage at school. The analysis results indicated that all proposed hypotheses were statistically significant, particularly confirming that secondary school students with internet usage experience exhibit higher levels of creative self-efficacy in science club activities. Finally, this study demonstrated the conflicting moderating effects of computer and smartphone use on the association between science club activities and creative self-efficacy. Therefore, the study emphasized the importance of science club activities supported by quality emotional support from teachers and the implementation of teaching and learning strategies that systematically manage ICT use among secondary school students.*

Keywords: *science club activity, creative self-efficacy, quality education, ICT usage, secondary school student*

Weimiao Wu, Kyung Hee Park
Woosuk University, Korea

Introduction

As technology and society continue to evolve rapidly, education must extend beyond focusing solely on academic achievement. Today's students need to develop essential 21st-century competencies, commonly summarized as the "4Cs", which include creativity, critical thinking, communication, and collaboration (Michael & Miranda, 2024). These competencies are essential for helping students face a digital and connected world. Beghetto (2006) and Farmer and Tierney (2017) have stressed the importance of designing school curricula that support creativity and convergent thinking. However, even though many educators agree on the importance of the 4Cs, these competencies are often treated as secondary or optional. In many classrooms, lecture-based, teacher-centered teaching methods still dominate, making it difficult to use more active and student-centered approaches that could better support the development of these important competencies.

In particular, since college advancement is central to educational policy in South Korea, the shift toward enhancing cognitive academic achievement in reading, writing, and arithmetic (3Rs) through teacher-centered education is progressing slowly. To address this educational challenge, the Korean Ministry of Education has expanded and supported creative experiential activities and club activities as part of its innovative education policy (Jung et al., 2015). Although the proportion of scheduled time allocated to these activities is not substantial, they promote the development of creativity and social skills through student-led academic experiences in areas such as science, computers, and citizenship (Kim & Kim, 2014). For instance, science club activities are conducted in various ways, including chemistry and physics experiments, robotics, environmental science exploration, participation in science and engineering competitions, and digital projects (Kwon et al, 2024). Similarly, France's "Science at School" policy is a nationwide program characterized by a cycle-based system that spans from kindergarten through secondary education (Carvalho et al., 2019). It particularly emphasizes the Fab Labs (Fabrication Laboratories) approach, which enables students to engage

https://doi.org/10.33225/jbse/25.24.969

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

in hands-on scientific experiences. Both South Korea and France share the common goal of encouraging students to experience science in a self-directed manner. However, while France provides continuous scientific experiences aligned with students' developmental stages, South Korea's science education is not systematically connected across different school levels. Through direct experience, students undergo personal growth and improve academic achievement (Lipscomb, 2007; Song et al., 2012; Williams & Gottfried, 2010). Eccles and Barber (1999) have found that students who engaged in school-based academic clubs achieved high school GPA outcomes that exceeded expectations. Therefore, it is essential to assess the effectiveness of these accumulated science club activities in fostering creative competencies to derive significant educational outcomes from these policies.

In an effort to improve learning outcomes, the international community has promoted an agenda called "quality education" under Sustainable Development Goal 4 (SDG4) since 2015. At this point, quality education encompasses the ability to achieve meaningful and effective learning outcomes (SDG 4.1) and emphasizes the professionalism and teaching-learning efforts of teachers (UN, 2015). In order to realize such quality education, teachers should provide learning opportunities and sufficient time to facilitate the implementation of personalized instruction for students (Osakwe, 2014). Furthermore, beyond traditional lecture-based teaching, teachers should continuously design and apply a variety of instructional activities to meet diverse learning needs (Krulj et al., 2024). Since the late 20th century, many countries have invested in information and communication technology (ICT) infrastructure within schools; however, such efforts have predominantly focused on the instructional applications of ICT by teachers. When ICT—recognized as a fundamental public good—is integrated into school settings in ways that mirror its everyday use in broader society, schooling can more effectively cultivate competencies that are closely linked to students' real-life experiences. Nevertheless, many schools worldwide tend to restrict students' Internet usage during school hours. However, this controlling trend requires improvement (UNESCO, 2023). It is essential to develop teaching and learning methods that transform these ICT activities into effective learning experiences, rather than merely restricting them from a control standpoint (Schaumburg, 2018).

Therefore, this study aimed to explore the effects of science club activities on creative self-efficacy, focusing on the mediating roles of quality education—specifically, quality teacher support and quality class support. Furthermore, from the perspective of creativity as the ability to explore and reconstruct information, this study examined how students' ICT-related experiences at school moderate this process. The results of this study are anticipated to offer valuable insights into the educational strategies that schools should adopt, both quantitatively and qualitatively, to foster the essential competencies required for students in the digital revolution era.

Literature Review

Science Club Activities at School

To cultivate scientifically literate citizens for the future, science education serves as a crucial educational tool that equips students to examine natural phenomena and address scientific challenges, thereby fostering creative problem-solving and integrative thinking. Currently, there has been a widespread lack of interest in the natural sciences among young people, as has been evidenced by international assessments (Krapp & Prenzel, 2011; Sahin, 2013). For instance, international assessments such as TIMSS and PISA have indicated that U.S. students are underperforming in mathematics and science, which threatens the United States' global leadership (Schmidt, 2011). A similar trend has been observed in South Korea, where student performance in science has consistently declined in recent years, as reported by the Organization for Economic Co-operation and Development (OECD, 2007).

To stimulate and sustain interest and curiosity in science, Hartley (2014) has emphasized the importance of adopting appropriate tools and engagement methods to involve young students in scientific exploration. Recent studies have confirmed that engagement in science club activities significantly enhances students' interest in science (Jung et al., 2015; Kim & Kim, 2014; Song & Lee, 2013). A science club is a gathering of individuals with shared interests, whether in school or the broader community, aimed at exchanging hobbies, skills, and values. Participation in such clubs has been shown to effectively improve students' adjustment to school and foster the development of their personality and emotional characteristics (Hur & Kang, 2010; Song et al., 2012).

While there is limited research assessing the association between field-specific extracurricular clubs and the effects of science education, the significance of student participation in these clubs has been widely recognized worldwide. Williams and Gottfried (2010) have confirmed that informal STEM exposure, both in-school and out-of-school, is critical to students' trajectories into (or out of) STEM-related careers. Additionally, according to Eccles and Barber (1999), school-based academic club involvement positively correlated with improved high school GPAs.

https://doi.org/10.33225/jbse/25.24.969

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

In examining how extracurricular club involvement influences STEM achievement, Lipscomb (2007) reported that participation in extracurricular clubs improved 2% and 1% gains in math and science test scores, respectively, among middle school students. It is evident that science club activities not only provide students with opportunities for hands-on and experimental research but also stimulate interest in science and foster the development of creative thinking. These activities have had a profound effect on students' personal growth, academic development, and future career choices (Kim & Kim, 2014; Lipscomb, 2007). Overall, science clubs serve as a vital educational resource globally, particularly in enhancing students' creative self-efficacy and promoting scientific literacy.

Creative Self-Efficacy Among Students

In this era of rapid change, the OECD (2014) identifies creativity as a critical competency that youth need to master in the 21st century. As the importance of innovation has grown, extensive research has explored the factors influencing innovativeness, with creativity self-efficacy being recognized as a crucial predictor of creative achievement and performance (Karwowski, 2011; Karwowski & Lebuda, 2016; Tierney & Farmer, 2002). Defined as individuals' belief in their capacity to generate creative outcomes (Tierney & Farmer, 2002), creative self-efficacy extends Bandura's (1997) broader concept of self-efficacy to the domain of creativity.

Creative self-efficacy is particularly important in educational settings because it influences students' motivation to participate in activities that foster creative thinking and problem-solving abilities. In particular, secondary school students (ages 12-18) represent a critical period for the development of self-efficacy, as their self-efficacy can significantly affect their academic performance, participation in extracurricular activities, and overall learning outcomes. For instance, Beghetto's (2006) study of secondary school students demonstrated that students with high creative self-efficacy tend to perceive academic success more positively and have greater motivation to learn. Furthermore, these students have shown greater engagement in extracurricular activities. Furthermore, Farmer and Tierney (2017) have emphasized that creative self-efficacy is a crucial motivational driver in education. Their cross-level study indicated that students who have strong creative self-efficacy are more likely to set and pursue challenging creative goals, engage persistently in problem-solving tasks, and maintain a positive outlook toward innovation. This underscored the central role of creative self-efficacy in fostering student motivation and engagement in learning.

Engagement in scientific learning and related activities serves a pivotal function in cultivating students' creative self-efficacy. Scientific learning often requires students to formulate hypotheses, design experiments, and develop innovative solutions to complex problems (Jung et al., 2015). These processes offer valuable opportunities for students to test their ideas, reflect on failures, and build confidence in their creative abilities. Such experiences enable students to overcome challenges and foster both creative thinking skills and a strong belief in their own creative potential. Research has shown that science learning environments promoting autonomy, problem-solving, and open-ended inquiry can significantly enhance students' creative self-efficacy (Beghetto, 2006; Tierney & Farmer, 2002). Currently, research on creative self-efficacy has primarily concentrated on the association between efficacy beliefs and creative outcomes. However, few studies have examined the predictors that influence creativity self-efficacy and the role of the school environment in this regard.

Quality Education in the Classroom

The United Nations Sustainable Development Goal 4 (UN-SDG4) emphasized the necessity of providing all students with equitable access to quality education, which is essential for achieving meaningful and effective learning outcomes (UN, 2015). In contemporary educational research, the concept of quality education is closely linked to the transfer of academic knowledge and the cultivation of learner competencies. To achieve these goals, dual support from teachers and the classroom environment is essential. Schools that provide such support are more likely to engage students, strengthen their connection to school, and promote effective learning outcomes (Klem & Connell, 2004).

Quality teacher support refers to the effective assistance and guidance provided by educators during teaching and learning activities. This support primarily encompasses both emotional and academic support for students (Birch & Ladd, 1997; Furrer & Skinner, 2003). Research has confirmed that teacher support fosters more positive teacher-student relationships and motivates students to engage in classroom activities (Ryan & Patrick, 2001), as well as to invest more energy in academic tasks (Boulton et al., 2012). Furthermore, teacher support plays a critical role in students' academic outcomes while also enhancing their academic mood. A meta-analysis has demonstrated

https://doi.org/10.33225/jbse/25.24.969

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

that teacher support is positively correlated with students' academic mood (Lei et al., 2018). Specifically, teacher support and encouragement can significantly enhance students' motivation and self-confidence in their learning (Hughes & Chen, 2011). Recent studies have also focused on how teacher support influences the creative self-efficacy of middle school students (Liu et al., 2021). It is believed that students who perceive a higher degree of teacher support exhibit greater autonomous motivation, which in turn contributes to increased creative self-efficacy.

Achieving quality education requires not only the support of teachers but also a quality class environment. Researchers and experts define quality education as authentic education that emphasizes the development of students' creativity, critical thinking, self-confidence, and other lifelong learning skills. Therefore, it is essential to support authentic education by promoting an effective classroom learning environment (Osakwe, 2014). Specifically, quality classroom support includes a range of elements such as learning resources, teaching methods, and classroom management. In particular, science club activities often adopt a hands-on and inquiry-based instructional approach, which requires a classroom environment that not only provides the necessary learning resources but also stimulates students' desire to explore. Numerous studies have demonstrated that support from the external environment plays a crucial role in stimulating students' intrinsic motivation (Krulj et al., 2024; Wu, 2003), and students' perceived classroom support has been identified as a vital component of the school environment. For instance, with the advancement of technology, research has shown that integrating emerging technologies into traditional classrooms to create smart learning environments can significantly increase student engagement and, consequently, maximize student potential (Wang et al., 2022).

Therefore, high-quality teacher support can help students maintain confidence when facing challenges and foster creative thinking through positive feedback. In turn, effective classroom support creates an open and resourceful environment that stimulates students' creative potential.

ICT-Usage at Schools

With the growing integration of information technology into the education sector, the integration of information and communication technology (ICT) in schools has emerged as a key driver of educational development. ICT has transformed teaching methodologies and significantly shaped students' learning experiences (Amutha, 2020). Research has indicated that the application of ICT in schools has a significantly positive effect on students' scientific literacy (Guo et al., 2022). Another study has shown that schools equipped with advanced ICT facilities enable students to more easily access scientific knowledge, conduct simulated scientific experiments, and engage in external academic interactions (Korukluğlu & Yucel-Toy, 2022). Such accessibility has not only improved learning efficiency but also stimulated students' interest and creativity in the learning process (Schaumburg, 2018).

With this trend, many governments worldwide have introduced policies to strengthen ICT infrastructure in educational institutions. For example, countries such as South Korea and Singapore have achieved levels of ICT integration in education comparable to those of the United Kingdom and the United States (Farrell & Wachholz, 2003). In recent years, developing countries have also increased their investments in educational ICT (Farrell & Wachholz, 2003). However, it is important to note that this advancement does not diminish the role of teachers. On the contrary, collaborative support among teachers and schools serves as a critical factor in realizing the full potential of ICT to facilitate student learning (Schaumburg, 2018).

ICT primarily encompasses various forms such as computers, internet access, and smartphones. The use of different types of ICT tends to yield varying effects on learning outcomes (Kates et al., 2018; Schaumburg, 2018). In classroom instruction, computers are generally categorized into two types of applications: information tools and learning tools. On one hand, students can use computers to search for information and enhance their fundamental academic skills; on the other hand, they can engage in scientific inquiry and participate in simulation-based experiments (Tondeur et al., 2007).

Furthermore, incorporating internet access into classroom teaching has been shown to support teachers in presenting instructional content more effectively, accelerating the pace of instruction, and increasing student engagement (Korukluğlu & Yucel-Toy, 2022; Schaumburg, 2018). However, these positive outcomes largely depend on teachers' levels of computer proficiency and their attitudes toward technology use in education (Julia & Dagmar, 2024; Tondeur et al., 2007).

Regarding the use of smartphones, students can utilize them to document key aspects of the learning process and share content through social or collaborative platforms, thereby enhancing peer interaction and discussion (Ilomäki, 2008; Zheng et al., 2021). Nevertheless, empirical studies have shown that the impact of smartphone use on positive learning outcomes is relatively limited (Frohberg et al., 2009; Hawiet & Samaha, 2016). Moreover, some

https://doi.org/10.33225/jbse/25.24.969

ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

researchers have expressed concerns that inappropriate or excessive use may lead to distraction and negatively affect students' academic performance (Gi et al., 2016).

Associations Between the Variables

Science club activities have been demonstrated to enhance students' interest in science and boost their academic motivation and confidence through practical, inquiry-based experiences (Hong et al., 2013; Jung et al., 2015). Such activities provide opportunities for creative expression and may serve as a foundation for the development of creative self-efficacy (Tierney & Farmer, 2002). However, achieving these benefits requires the reinforcement of high-quality education, in which teachers play an indispensable role.

In particular, quality education—including teacher support and a positive classroom environment—may mediate the association between participation in science club activities and creative self-efficacy. Based on Self-Determination Theory, environments that promote autonomy and provide constructive feedback foster students' intrinsic motivation, which is closely linked to creativity (Deci & Ryan, 2000). Empirical studies have demonstrated that teacher support and classroom dynamics significantly enhance students' creative self-efficacy (Beghetto, 2006; Puozzo & Audrin, 2021). Consequently, the mediating model proposed in this study is illustrated in Figure 1.

Moreover, the ICT environment in schools, as a critical component of the learning context, may influence the effect of science club activities on students' creative self-efficacy. Specifically, during science club activities, students may use computers for data analysis and experimental simulations; access the internet to consult the latest scientific findings and participate in online academic discussions; and utilize smartphones to conduct field investigations and record observations, thereby promoting peer communication and interaction (Korukluoğlu & Yucel-Toy, 2022). Accordingly, this study constructed a moderated mediation model to examine how three specific dimensions of ICT usage in schools—computer use, internet access, and smartphone usage—moderate the associations within the model (shown in Figure 2).

Understanding these associations, this study provided insights into how science club activities contribute to creative self-efficacy among Korean secondary school students. Specifically, it examined whether quality education—represented by teacher support and classroom environment—mediates this correlation, and whether students' ICT usage at school moderates this effect.

This study posed the following three research questions:

Are science club activities effective in enhancing creative self-efficacy in secondary school students?

Does quality education mediate the association between science club activities and creative self-efficacy?

Does ICT usage at school (computer, internet access, smartphone) moderate the mediating effect of quality education?

Figure 1
Partial Mediating Model

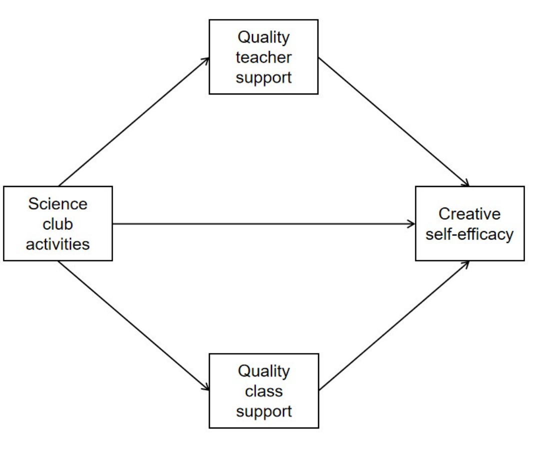
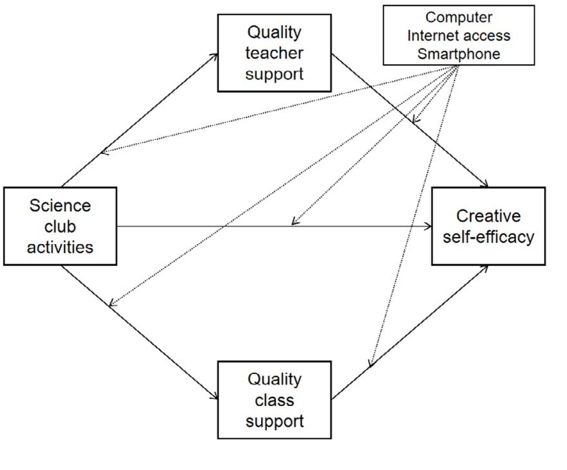


Figure 2
Moderating Model by Multi-group



https://doi.org/10.33225/jbse/25.24.969

ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

Research Methodology

Design

A quantitative research design was adopted in this study, drawing on data from the 2022 Program for International Student Assessment (PISA 2022). It focused on analyzing the potential correlations between participation in science club activities, quality education, and creative self-efficacy among secondary school students in South Korea. The research specifically targets 16-year-old secondary school students who participated in the PISA assessment, providing a nationally representative dataset of their educational experiences and competencies. The data were analyzed using structural equation modeling (SEM).

Participants

The analysis was based on the PISA 2022 survey data for South Korean secondary school students. The OECD has conducted the PISA assessment every three years, aiming to evaluate the abilities and competencies of students worldwide in preparing for future life challenges. The 2022 PISA assessment involved around 690,000 students across 81 countries and economies. The students in this study were between 16 and 17 years old and had completed at least six years of formal education at the time of testing. The data included a sample of students from various academic ability levels, ensuring the representativeness and diversity of the sample.

A total of 6,454 South Korean student samples participated in this study, and after excluding 717 incomplete samples, 5,737 valid responses were included in the analysis. The gender distribution was nearly equal, comprising 2,922 male students (50.9%) and 2,815 female students (49.1%). In terms of age, the majority of the sample consisted of 16-year-old students (5,400, or 94.1%), while 337 students were aged 17 (5.9%). Additionally, the study examined the distribution of students' ICT usage at school. A total of 3,720 students (64.8%) reported having used computer at school, while 2,017 students (35.2%) did not; 3,752 students (65.4%) reported that their school was accessed internet, while 1,985 students (34.6%) did not; 4,899 students (85.4%) reported having used a smartphone at school, while 838 students (14.6%) did not. Table 1 provides an overview of the participants' demographic characteristics.

Table 1
Demographics of Participants

Variables		Items	*N*	%
Gender		Male	2,922	50.9
		Female	2,815	49.1
Age		16	5,400	94.1
		17	337	5.9
ICT usage at school	Computer	Inexperienced	3,720	64.8
		Experienced	2,017	35.2
	Internet access	Inexperienced	3,752	65.4
		Experienced	1,985	34.6
	Smartphone	Inexperienced	4,899	85.4
		Experienced	838	14.6
Total			5,737	100.0

Measurements

To validate the research model, the following construct variables were evaluated using the PISA questionnaire. First, participation in science club activities at school was assessed using the question, "In your school, how often do you participate in science club activities?" The responses for this question used a Likert scale ranging from 'Never'

https://doi.org/10.33225/jbse/25.24.969

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

to 'Every Day,' with an additional option of 'Not Available at School.' The scale was scored on a 6-point scale, where a higher score indicated a greater level of participation in science club activities.

Next, quality teacher support refers to the effective assistance and guidance provided by educators during educational activities. It was assessed using the question, "Do you agree that my teachers allow me sufficient time to develop creative solutions to assignments?" A Likert scale was used for this item, ranging from 'Strongly Disagree' to 'Strongly Agree,' with higher values signifying stronger positive perceptions of teacher support. For quality class support, this study utilized the question, "Do you agree that the activities we engage in during my classes help you think of new ways to solve problems?" This was also assessed using a Likert scale, where higher scores indicated stronger agreement with the statement.

Additionally, to measure the frequency of students' ICT usage at school, three items were employed: computer, Internet access, and smartphone. Students were asked how often they used (1) desktop or laptop computers, (2) Internet access (excluding smartphones), and (3) smartphones (i.e., mobile phones with Internet access) at school. Participants responded using a 5-point Likert scale, with options ranging from 'Never' to 'Several times a day'. Higher scores indicated more frequent use of each ICT tool during school hours.

Finally, students rated their confidence in performing a variety of tasks that reflect creative skills. For instance, two of the items included "How confident are you about coming up with creative ideas for school projects?" and "How confident are you about thinking of many good ideas for science experiments?" Each of the eight items in this scale provided four response options: 'Not at all confident' to 'Extremely confident.' Creative self-efficacy demonstrated acceptable internal consistency, as evidenced by a Cronbach's alpha of .966.

Data Analysis

Multiple statistical analyses were conducted to assess the quality and reliability of the collected data. The data analysis process began with descriptive statistics to understand the basic characteristics of the sample, including the mean, standard deviation, and range of each variable. Next, to further examine the effect of ICT usage (computers, internet access, and smartphones) experience on students' participation in science club activities and their creative self-efficacy, an independent samples t-test was conducted. The sample was divided into two groups based on whether students had ICT usage experience at school. This test allowed for the assessment of whether ICT usage experience significantly influenced these variables. After conducting preliminary analyses using descriptive statistics and the t-test, the study constructed a Structural Equation Model (SEM) to validate the mediating role of quality education between participation in science club activities and creative self-efficacy. To ensure the model's applicability, AMOS 26.0 software was utilized for model fitting, and the model was evaluated based on fit indices such as the Comparative Fit Index (CFI) and the Tucker-Lewis Index (TLI). Finally, considering that ICT usage may have a moderating effect across different student groups, a Multi-Group Analysis was performed to examine how ICT usage moderated the aforementioned pathways.

Research Results

Differences in ICT Usage at School

To understand the levels of students' engagement in science club activities, quality education, and creative self-efficacy, this study examined differences in the use of computers, internet access, and smartphones at school (see Table 2).

An independent samples t-test revealed statistically significant differences ($p < .001$) between students with and without computer usage experience in terms of science club activities ($t = 8.20$), quality teacher support ($t = 4.77$), quality class support ($t = 5.71$), and creative self-efficacy ($t = 6.67$). Students with and without internet access experience at school showed significant differences ($p < .001$) in science club activity ($t = 9.43$), quality teacher support ($t = 4.83$), quality class support ($t = 5.90$), and creative self-efficacy ($t = 7.33$). These results indicated that students with relevant experience outperformed those without computer and internet access at school in science club activities, quality teacher support, quality class support, and creative self-efficacy. Additionally, there were significant differences ($p < .01$) between students with and without smartphone usage experience in terms of creative self-efficacy ($t = 3.06$). The findings confirmed that students with smartphone usage experience at school had higher levels of creative self-efficacy.

https://doi.org/10.33225/jbse/25.24.969

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Table 2
Comparing the Differences in ICT Usage at School

Construct		Science club activities		Quality teacher support		Quality class support		Creative self-efficacy	
		M (*SD*)	*t*	*M* (*SD*)	*t*	*M* (*SD*)	*t*	*M* (*SD*)	*t*
Total		2.12 (1.47)	–	2.78 (0.67)	–	2.77 (0.70)	–	2.61 (0.73)	–
Computer	Experienced	2.23 (1.50)	8.20***	2.82 (0.66)	4.77***	2.81 (0.69)	5.71***	2.66 (0.73)	6.67***
	Inexperienced	1.91 (1.40)		2.73 (0.68)		2.70 (0.71)		2.53 (0.74)	
Internet access	Experienced	2.25 (1.48)	9.43***	2.82 (0.65)	4.83***	2.81 (0.68)	5.90***	2.66 (0.72)	7.33***
	Inexperienced	1.87 (1.42)		2.72 (0.70)		2.69 (0.74)		2.51 (0.75)	
Smartphone	Experienced	2.13 (1.45)	1.43	2.79 (0.66)	1.69	2.78 (0.69)	1.57	2.63 (0.73)	3.06**
	Inexperienced	2.05 (1.57)		2.75 (0.70)		2.73 (0.75)		2.54 (0.77)	

Note. $^{**}p < .01$, $^{***}p < .001$

Verification of the Mediating Effect of Quality Education

To further analyze the associations among science club activities, quality education, and creative self-efficacy, a mediation effect test was conducted on the two dimensions of quality education (quality teacher support and quality class support). As shown in Table 3, the model fit values for the full sample were $\chi^2/df = 120.465$ ($p < .001$), with both the TLI and CFI exceeding 0.90, thereby meeting the acceptance criteria.

As shown in Table 4, all path results were statistically significant ($p < .001$), providing strong support for the correlations among the variables in the model. Specifically, the independent variable (science club activities) had a positive influence on both the dependent variable (creative self-efficacy) and the mediator variables (quality teacher support and quality class support) ($\beta = .060$, $p < .001$; $\beta = .047$, $p < .001$; $\beta = .059$, $p < .001$). In particular, the mediator variables (quality teacher support and quality class support) also positively influenced the dependent variable (creative self-efficacy) ($\beta = .167$, $p < .001$; $\beta = .157$, $p < .001$). These results suggest that as students perceive higher quality education, their creative self-efficacy is likewise enhanced. The final model's path coefficient results are illustrated in Figure 3.

Additionally, a bootstrapping method was employed to verify the mediation effect, with a sample size of 2,000. As shown in Table 5, both quality teacher support and quality class support had a significant effect on science club activities and creative self-efficacy, with indirect effect values of .008 and .009, respectively. The confidence intervals did not include zero, and the p-values were less than .001, thereby confirming their mediating roles. Consequently, these results emphasize that improving the quality of education is essential for promoting students' creative self-efficacy.

https://doi.org/10.33225/jbse/25.24.969

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Figure 3
Path Diagram and Standardized Estimate of Research Model

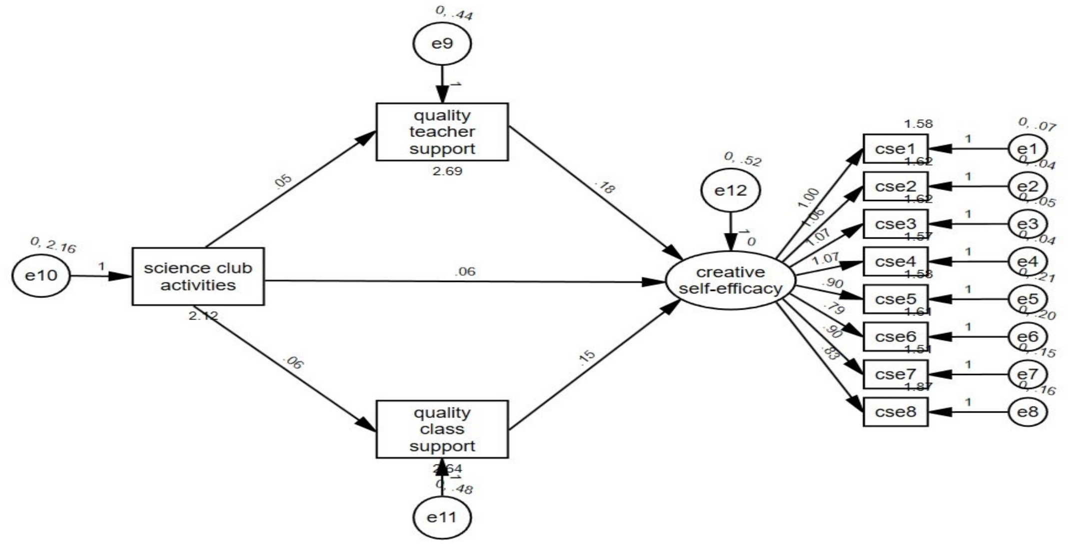


Table 3
Fit indices for the Research Model

Model	*df*	χ²/*df*	*TLI*	*CFI*
Full sample	42	120.465***	.907	.929

Note. ****p* < .001

Table 4
Significance Verification for the Research Model

Path	β	*SE*	Bootstrap 2000 times 95% bias-corrected CI
Science club activities → Quality teacher support	.047***	.006	.035 ~ .058
Science club activities → Quality class support	.059***	.006	.047 ~ .072
Science club activities → Creative self-efficacy	.060***	.006	.048 ~ .072
Quality teacher support → Creative self-efficacy	.167***	.020	.128 ~ .206
Quality class support → Creative self-efficacy	.157***	.019	.119 ~ .194

Note. ****p* < .001

Table 5
Significance Verification of Mediating Effect

Path	β	*SE*	Bootstrap 2000 times 95% bias-corrected CI
Science club activities → Quality teacher support → Creative self-efficacy	.008***	.002	.005 ~ .011
Science club activities → Quality class support → Creative self-efficacy	.009***	.002	.006 ~ .013

Note. ****p* < .001

https://doi.org/10.33225/jbse/25.24.969

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Verification of Multi-group Comparison for ICT Usage

Finally, multi-group analyses were conducted to verify the moderating effects of computer use, internet access, and smartphone usage in schools. The results indicated that the model fit for the multi-group analysis met the established acceptance criteria, as shown in Table 6.

The findings indicated that science club activities in both groups, with and without computer usage at school, had a significant positive effect on quality education ($p < .001$), and quality education also had a significant positive effect on creative self-efficacy ($p < .001$). Since the differences in the paths from 'science club activities → quality class support' and 'quality teacher support → creative self-efficacy' between groups with and without computer usage experience were -2.154 and -2.802, respectively, all of which were greater than |1.96|, indicating that these path differences were statistically significant. Since the differences in all paths between groups with and without internet access at school did not meet the acceptance criteria, indicating that all path differences were not statistically significant.

Regarding smartphones, the findings revealed that science club activities in both groups—with and without smartphone usage at school—had a significant positive effect on quality education ($p < .001$). Additionally, quality education had a significant positive effect on creative self-efficacy ($p < .001$). The differences in the paths from 'quality teacher support → creative self-efficacy' and 'quality class support → creative self-efficacy' between groups with and without smartphone usage experience were 3.643 and -1.993, respectively. Both values exceed the critical value of |1.96|, indicating that these path differences were statistically significant. As a result, the moderating effect of smartphone use at school was confirmed, and the mediating effect of quality teacher support (β = .269) was found to be stronger in the group that did not use smartphones (see Table 7).

Table 6
Nested Multi-Group Model Fits

Structural residuals	*df*	*χ²/df*	*TLI*	*CFI*
Computer	111	47.443***	.927	.926
Internet access	111	47.849***	.926	.926
Smartphone	111	46.519***	.929	.928

Note. ****p* < .001

Table 7
Significance Verification of Multi-group Path Analysis

Path	Inexperienced		Experienced		Between groups
	β	*SE*	β	*SE*	
Path toward Computer					
Science club activities → Quality teacher support	.117***	.007	.057*	.011	-1.852
Science club activities → Quality class support	.142***	.007	.071**	.011	-2.154
Science club activities → Creative self-efficacy	.110***	.008	.093***	.012	-.293
Quality teacher support → Creative self-efficacy	.185***	.018	.109***	.025	-2.802
Quality class support → Creative self-efficacy	.141***	.017	.143***	.023	.019
Path toward Internet access					
Science club activities → Quality teacher support	.099***	.007	.088***	.011	.036
Science club activities → Quality class support	.131***	.007	.089***	.012	-.959
Science club activities → Creative self-efficacy	.100***	.008	.111***	.012	.721
Quality teacher support → Creative self-efficacy	.170***	.018	.133***	.024	-1.572
Quality class support → Creative self-efficacy	.136***	.017	.155***	.023	.414

https://doi.org/10.33225/jbse/25.24.969

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Path	Inexperienced		Experienced		Between groups
	β	*SE*	β	*SE*	
Path toward Smartphone					
Science club activities → Quality teacher support	.103***	.006	.095**	.015	-.290
Science club activities → Quality class support	.126***	.007	.117***	.016	-.216
Science club activities → Creative self-efficacy	.103***	.007	.152***	.017	-1.317
Quality teacher support → Creative self-efficacy	.139***	.016	.269***	.037	3.643
Quality class support → Creative self-efficacy	.153***	.015	.085**	.035	-1.993

Note. *$p < .05$, **$p < .01$, ***$p < .001$

Discussion

This study quantitatively analyzed the academic effects of science club activities on secondary school students, and the main results are as follows.

First and foremost, the research revealed that participation in science club activities significantly contributed to the enhancement of creative self-efficacy among secondary school students. This finding was consistent with previous studies, such as those by Hartley (2014), Kwon et al. (2024), and Song et al. (2012), which emphasized the importance of science club activities in fostering creative and transformative competencies. While the dependent variable of this study, creative self-efficacy, is characterized by non-cognitive traits rather than being directly measurable as creativity, it is important to note that the emotional attitudes associated with efficacy are linked to practical capabilities (Beghetto, 2006; Karwowski & Lebuda, 2016; Tierney & Farmer, 2002). In addition to enhancing creative competencies, the club-based science learning focused on in this study had various educational effects. Lipscomb (2007) demonstrated that interactive learning reinforces problem-solving skills and teamwork, while Kim and Kim (2014) highlighted the development of social skills through school club activities. Given that the convergent competencies, as the 4Cs required in the digital society, encompass not only creativity but also communication and collaboration, it is essential to actively promote student-led club activities in the future.

Moreover, this study confirmed that the quality of teaching and learning provided by teachers in the classroom further strengthened the causal association between science club activities and creative self-efficacy, serving as a mediating factor. When teachers allocated sufficient time for students to creatively develop solutions and engaged them in classroom activities that facilitated problem-solving, the creative self-efficacy of secondary school students was found to be significantly enhanced. This finding aligns with the suggestion by Dearden et al. (2002) that selective schools tend to achieve better educational outcomes. Dearden et al. (2002) indicated that when controlling for ability and family background, there was generally no significant association between educational quality and academic achievement. This observation is consistent with the educational equity theory of Coleman et al. (1966), who found that the effect of educational conditions was minimal. However, Gerick and Killus (2024), along with Dearden et al. (2002) and Rutter (1983), asserted that the educational effects of specialized classes and tailored support from teachers may vary, which aligns with the results of this research. In other words, offering advanced educational support, beyond the basic quality education (e.g., student-to-teacher ratio) provided to all students, results in positive learning outcomes. This argument regarding the importance of careful and emotional support from teachers has also been highlighted in studies by Hughes and Chen (2011), Lei et al. (2018), and Liu et al. (2021).

Next, concerning the variation in Internet usage among secondary schools across different countries, this study confirmed that students should develop tolerance towards Internet use in order to effectively engage with the digital society. Apart from the United States and Germany, most countries, including South Korea, restrict secondary school students from accessing the Internet during school hours. In contrast, this study revealed that secondary school students who experienced Internet use in schools were more active in science club activities and exhibited significantly higher levels of creative efficacy. The mean science club activity score for students with Internet experience at school was 2.25, while the score for students without Internet experience was 1.87, indicating a significant difference between the two groups. Additionally, the mean score for creative self-efficacy based on Internet use experience was 2.66 for those with experience and 2.51 for those without, also demonstrating a significant difference. Schaumburg (2018) and Tonderur et al. (2007) reported similar findings, confirming that Internet use experience in school enhances learning efficiency. This study confirmed that the educational effect

https://doi.org/10.33225/jbse/25.24.969

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

of smartphone use is relatively minor compared to that of Internet use in schools. In particular, the difference in science club activities based on smartphone use was not significant (t = 1.43), which aligns with the finding of Kates et al. (2018). These research results suggest that positive learning effects may vary depending on the type of ICT employed.

Furthermore, this study empirically demonstrated the conflicting moderating effects of ICTs, such as computer and smartphone usage, on the association between science club activities and the creative self-efficacy of secondary school students. The findings indicated that for students with experience using computers in schools, the effect of high-quality teacher support on creative self-efficacy was notably more pronounced. The results of this study's Multi-Group SEM analysis demonstrated a significantly more influential causal association among students who had utilized the computers in schools. These results suggest that teacher support for computer use in schools should be both intentional and strategic (Julia & Dagmar, 2024; Korukluğlu & Yucel-Toy, 2022).

In contrast, this study found that the effect of science club activities on creative self-efficacy was significantly higher among students who did not use smartphones at secondary school. Similarly, Frohberg et al. (2009) confirmed the relatively insignificant effect of mobile learning and emphasized the necessity for teacher oversight and intervention. In light of the findings regarding significant differences in creative self-efficacy based on smartphone usage, it can be concluded that smartphone use has a more detrimental effect on fostering positive learning outcomes than on the diverse knowledge and information acquired through it. In this context, Hawi and Samaha (2016) expressed concerns about smartphone addiction in educational settings and empirically demonstrated that excessive smartphone use does not correlate with high academic achievement. Notably, many European countries have recently imposed restrictions on smartphone usage in schools due to concerns about distractions (Julia & Dagmar, 2024; UNESCO, 2023). The key is for teachers to acknowledge the potential issue that smartphone use in schools may lead to students' lack of self-control, while also recognizing that appropriate interventions for ICT use can foster resilience to uncertainty and enhance creative self-efficacy.

Conclusions and Implications

The purpose of the current study was to analyze the mediating effect of quality education provided by teachers in the association between science club activities and secondary school students' creative self-efficacy. The research findings confirmed that time-based and supportive teaching and learning in the classroom significantly enhance creative self-efficacy. Additionally, a key finding of this study revealed that secondary school students who had experience using the Internet at school tended to exhibit higher levels of creative self-efficacy due to their engagement in science club activities.

The research findings underscored the importance of quality educational considerations that teachers can implement beyond the standards of national-level education. This study demonstrated the significance of allocating sufficient time for thoughtful consideration and providing active support for creative and problem-solving learning activities, which are crucial for academic achievement. In particular, it is essential to emphasize that for science experiential activities to significantly enhance students' creative self-efficacy, continuous management and operational systems tailored to each school level (from elementary to secondary) must be established as a prerequisite. Furthermore, a long-term vision and educational strategy at the national level must be developed to broaden the effect of science education, extending from personal development to future career choices.

In addition, this study offered an opportunity to explore the positive effects and challenges associated with the culture of Internet use in schools. This has significant implications for how schools should adapt in the context of a digital society. The fact that many countries are implementing policies to ban the use of ICT in schools indicates that the negative effects of ICT use cannot be overlooked. Nevertheless, in light of this study and UNESCO's assertions within the international community, it is timely to minimize these negative effects and develop strategies for teachers to effectively manage ICT usage. Teachers should exercise caution to prevent students from using ICT indiscriminately, as it may hinder their engagement in learning. Moreover, for students' ICT use to contribute to positive academic achievement, teachers should first comprehend students' ICT literacy and the frequency of their usage. To this end, this study suggested that teachers engage with students on a daily basis and utilize the insights gained from these interactions as diagnostic data. And they should strive to leverage the accumulated student data to enhance their teaching strategies and improve their ability to implement classes that effectively utilize ICT. Therefore, the state and schools that lead the education system need to make efforts to create an environment that enables teachers to deliver quality education and enhances support for their professional roles. Educational institutions should not limit themselves to merely distributing ICT equipment; instead, they should

https://doi.org/10.33225/jbse/25.24.969

ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

closely integrate structural elements such as teacher training, curriculum development, and the cultivation of a positive school culture.

In this context, further research is necessary to explore the effect on student achievement at both the teacher and school levels. Given that students' use of ICT is more active outside of school as well as within it, it is essential to clarify the causal association between variables within the student-teacher-school-society structure from an ecological perspective. Additionally, follow-up research needs to consider that the effects of informal and non-formal education, alongside the formal education students receive at school, are closely interconnected.

It is also valuable to examine the types of change processes that occur in educational experiences using a qualitative approach. As students progress through different school levels, their cumulative experiences in science education may be assessed differently from their experiences at a cross-sectional level. By exploring longitudinal changes in creative self-efficacy in relation to their science learning experiences, educational institutions can develop more targeted support measures to enhance students' academic achievement.

Declaration of Interest

The authors declare no competing interests.

References

Amutha, D. (2020). The role and impact of ICT in improving the quality of education. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3585228

Bandura, A. (1997). *Self-efficacy: The exercise of control*. Freeman. https://doi.org/10.1891/0889–8391.13.2.158

Beghetto, R. A. (2006). Creative self-efficacy: Correlates in middle and secondary students. *Creativity Research Journal*, *18*(4), 447–457. https://doi.org/10.1207/s15326934crj1804_4

Birch, S. H., & Ladd, G. W. (1997). The teacher-child relationship and children's early school adjustment. *Journal of School Psychology*, *35*(1), 61–79. https://doi.org/10.1016/S0022-4405(96)00029-5

Boulton, M., Lloyd, J., Down, J., & Marx, H. (2012). Predicting undergraduates' self-reported engagement in traditional and cyberbullying from attitudes. *Cyberpsychology, Behavior, and Social Networking*, *15*(3), 141–147. https://doi.org/10.1089/cyber.2011.0369

Carvalho, V. B. D., Massarani, L., & Macedo-Rouet, M. (2019). Science, television, and adolescents: A comparative study of France and Brazil. *Educação e Pesquisa, 45*, 1–19. https://doi.org/10.1590/S1678-4634201945213888

Coleman, J. S. (1966). Equality of educational opportunity. *Integrated Education*, *6*(5), 19–28. https://doi.org/10.1080/0020486680060504

Dearden, L., Ferri, J., & Meghir, C. (2002). The effect of school quality on educational attainment and wages. *Review of Economics and Statistics*, *84*(1), 1–20. https://doi.org/10.1162/003465302317331883

Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, *11*, 227–268. https://doi.org/10.1207/S15327965PLI1104_01

Eccles, J., & Barber, B. (1999). Student council, volunteering, basketball, or marching band: What kinds of extracurricular involvement matter? *Journal of Adolescent Research*, *14*, 10–43. https://doi.org/10.1177/0743558499141003

Farmer, S. M., & Tierney, P. (2017). Considering creative self-efficacy: Its current state and ideas for future inquiry. In M. Karwowski & J. C. Kaufman (Eds.), *The creative self* (pp. 23–47). Academic Press. https://doi.org/10.1016/B978-0-12-809790-8.00002-9

Farrell, G., & Wachholz, C. (2003). Introduction: Meta-survey on the use of technologies in education in Asia and the Pacific. In G. Farrell & C. Wachholz (Eds.), *ICT in education* (pp. 2003–2004). http://www.unescobkk.org/index.php?id=1807

Frohberg, D., Göth, C., & Schwabe, G. (2009). Mobile learning projects–a critical analysis of the state of the art. *Journal of Computer Assisted Learning*, *25*(4), 307–331. https://doi.org/10.1111/j.1365-2729.2009.00315.x

Furrer, C., & Skinner, E. (2003). Sense of relatedness as a factor in children's academic engagement and performance. *Journal of Educational Psychology*, *95*(1), 148–162. https://doi.org/10.1037/0022-0663.95.1.148

Gerick, J., & Killus, D. (2024). Tolerance of uncertainty and its role for teachers' use of ICT in classroom in times of digital transformation. *Zeitschrift für Bildungsforschung*, 1–18. https://doi.org/10.1007/s35834-024-00431-y

Guo, Q., Qiao, C., & Ibrahim, B. (2022). The mechanism of influence between ICT and students' science literacy: A hierarchical and structural equation modelling study. *Journal of Science Education and Technology*, *31*(2), 272–288. https://doi.org/10.1007/s10956-021-09954-9

Hartley, M. S. (2014). Science clubs: An underutilized tool for promoting science communication activities in school. In L. T. W. Hin & R. Subramaniam (Eds.), *Communicating science to the public: Opportunities and challenges for the Asia-Pacific region* (pp. 21–31). Springer Netherlands. https://doi.org/10.1007/978-94-017-9097-0_2

Hawi, N. S., & Samaha, M. (2016). To excel or not to excel: Strong evidence on the adverse effect of smartphone addiction on academic performance. *Computers & Education*, *98*, 81–89. https://doi.org/10.1016/j.compedu.2016.03.007

Hong, J. C., Chen, M. Y., & Hwang, M. Y. (2013). Vitalizing creative learning in science and technology through an extracurricular club: A perspective based on activity theory. *Thinking Skills and Creativity*, *8*, 45–55. https://doi.org/10.1016/j.tsc.2012.06.001

Hughes, J. N., & Chen, Q. (2011). Reciprocal effects of student-teacher and student-peer relatedness: Effects on academic self-efficacy. *Journal of Applied Developmental Psychology*, *32*, 278–287. https://doi.org/10.1016/j.appdev.2010.03.005

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Hur, C.-S., & Kang, O.-Y. (2010). The comparison of self-efficacy between the youths involved in circle activities and the youths not involved. *Korean Association of Adolescent Welfare*, *12*(3), 25–46. https://kiss.kstudy.com/Detail/Ar?key=2879776

Ilomäki, L. (2008). *The effects of ICT on school: teachers' and students' perspectives.* Annales Universitatis Turkuensis B 314. https://urn.fi/URN:ISBN:978-951-29-3684-7

Julia, G., & Dagmar, K. (2024). Tolerance of uncertainty and its role for teachers' use of ICT in classroom in times of digital transformation. *Empirischer Originalbeitrag*, *14*, 339–356. https://doi.org/10.1007/s35834-024-00431-y

Jung, J., Wee, S., & Lim, S. (2015). Impact of science club activities associated with STEAM activities on students' self-efficacy and attitudes toward science. *Journal of Korean Society of Earth Science Education*, *8*(2), 183–192. https://doi.org/10.15523/JKSESE.2015.8.2.183

Jung, J., & Lee, S. (2025). An international comparative study of student- and school-level ICT factors affecting mathematics achievement. *Educational Science Research*, *56*(2), 137–161. https://doi.org/10.15854/jes.2025.06.56.2.137

Karwowski, M. (2011). It doesn't hurt to ask… But sometimes it hurts to believe: Polish students' creative self-efficacy and its predictors. *Psychology of Aesthetics, Creativity, and the Arts*, *5*, 154–164. https://doi.org/10.1037/a0021427

Karwowski, M., & Lebuda, I. (2016). The big five, the huge two, and creative self-beliefs: A meta-analysis. *Psychology of Aesthetics, Creativity, and the Arts*, *10*, 214–232. https://doi.org/10.1037/aca0000035

Kates, A. W., Wu, H., & Coryn, C. L. S. (2018). The effects of mobile phone use on academic performance: A meta-analysis. *Computers & Education*, *127*, 107–112. https://doi.org/10.1016/j.compedu.2018.08.012

Kim, J., & Kim, J. (2014). The changes of attitude related to science of students in the high school science club through the creative-experience activity of science field. *Journal of Science Education*, *38*(3), 471–489. https://koreascience.kr/article/JAKO201429561845692.pdf

Klem, A. M., & Connell, J. P. (2004). Relationships matter: Linking teacher support to student engagement and achievement. *Journal of School Health*, *74*(7). https://www.viriya.net/jabref/relationships_matter_linking_teacher_support_to_student_engagement_and_achievement.pdf

Korukluoğlu, P., & Yucel-Toy, B. (2022). Digital storytelling in online elementary science education: A case study on science and technology club activities. *International Journal of Science Education*, *44*(17), 2541–2564. https://doi.org/10.1080/09500693.2022.2138727

Krapp, A., & Prenzel, M. (2011). Research on interest in science: Theories, methods, and findings. *International Journal of Science Education*, *33*(1), 27–50. https://doi.org/10.1080/09500693.2010.518645

Krulj, J. R., Marković, E., Simijonović, I., & Lazović, N. R. (2024). Intrinsic and extrinsic motivation within the context of creating a stimulating learning environment. *Društvene i humanističke studije*, *9*(2), 1329–1344. https://doi.org/10.51558/2490-3647.2024.9.2.1329

Kwon, Y., Lee, H., & Yoon, S. (2024). Students' cognition on the experience of science club activities based on AI convergence education of middle school students. *TER*, *63*(4), 580–600. https://doi.org/10.15812/ter.63.4.202412.580

Lei, H., Cui, Y., & Chiu, M. M. (2018). The relationship between teacher support and students' academic emotions: A meta-analysis. *Frontiers in Psychology*, *8*, 2288. https://doi.org/10.3389/fpsyg.2017.02288

Lipscomb, S. (2007). Secondary school extracurricular involvement and academic achievement: A fixed effects approach. *Economics of Education Review*, *26*, 463–472. https://doi.org/10.1016/j.econedurev.2006.02.006

Liu, X. X., Gong, S. Y., Zhang, H. P., Yu, Q. L., & Zhou, Z. J. (2021). Perceived teacher support and creative self-efficacy: The mediating roles of autonomous motivation and achievement emotions in Chinese junior high school students. *Thinking Skills and Creativity*, *39*, 100752. https://doi.org/10.1016/j.tsc.2020.100752

Michael, A., & Miranda, J. (2024). *How schools transform: Practices, research, and actions that change schools.* Bloomsbury Academic. https://doi.org/10.5040/9781350293366

Organization for Economic Cooperation and Development (OECD). (2007). *PISA 2006 science competencies for tomorrow's world*. OECD. https://www.oecd.org/en/publications/pisa-2006_9789264040014-en.html

Organization for Economic Cooperation and Development (OECD). (2014). *PISA 2012 results: Creative problem solving*. OECD. https://www.oecd.org/en/publications/pisa-2012-results-skills-for-life-volume-v_9789264208070-en.html

Organization for Economic Cooperation and Development (OECD). (2023). *PISA 2022 assessment and analytical framework*. OECD. https://www.oecd.org/en/publications/2023/08/pisa-2022-assessment-and-analytical-framework_a124aec8.html

Osakwe, R. N. (2014). Classroom management: A tool for achieving quality secondary school education in Nigeria. *International Journal of Education*, *6*(2), 58. https://doi.org/10.5296/ije.v6i2.5616

Puozzo, I. C., & Audrin, C. (2021). Improving self-efficacy and creative self-efficacy to foster creativity and learning in schools. *Thinking Skills and Creativity*, *42*, 100966. https://doi.org/10.1016/j.tsc.2021.100966

Rutter, M. (1983). School effects on pupil progress: Research findings and policy implications. *Child Development*, 1–29. https://doi.org/10.2307/1129857

Ryan, A. M., & Patrick, H. (2001). The classroom social environment and changes in adolescents' motivation and engagement during middle school. *American Educational Research Journal*, *38*(2), 437–460. https://doi.org/10.3102/00028312038002437

Sahin, A. (2013). STEM clubs and science fair competitions: Effects on post-secondary matriculation. *Journal of STEM Education*, *14*(1), 5–11. https://www.jstem.org/jstem/index.php/JSTEM/article/view/1781

Schaumburg, H. (2018). Empirische befunde zur wirksamkeit unterschiedlicher konzepte des digital unterstützten lernens. In McElvany, N., Schwabe, F., Bos, W., & Holtappels, H. G. (Eds.), *Digitalisierung in der schulischen Bildung* (pp. 27–40), Waxmann Verlag.

Schmidt, W. H. (2011). STEM reform: Which was to go? In *National Research Council Workshop on Successful STEM Education in K-12 Schools*. https://www.mspnet.org/projects/promse/23223.html

https://doi.org/10.33225/jbse/25.24.969

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Seo, D. G., Park, Y., Kim, M. K., & Park, J. (2016). Mobile phone dependency and its impacts on adolescents' social and academic behaviors. *Computers in Human Behavior*, *63*, 282–292. https://doi.org/10.1016/j.chb.2016.05.026

Snow-Gerono, J. L. (2005). Professional development in a culture of inquiry: PDS teachers identify the benefits of professional learning communities. *Teaching and Teacher Education*, *21*(3), 241–256. https://doi.org/10.1016/j.tate.2004.06.008

Song, K., & Lee, K. (2013). Development and application of experiential activity program for science club in middle school. *Journal of Science Education*, *38*(1), 23–37.

Song, S., Kim, J., & Namgung, J. (2012). The effects of adolescents' experience of club activities on their self-concept. *Studies on Korean Youth*, *23*(1), 121–147. https://kiss.kstudy.com/Detail/Ar?key=4046564

Tierney, P., & Farmer, S. M. (2002). Creative self-efficacy: Its potential antecedents and relationship to creative performance. *Academy of Management Journal*, *45*, 1137–1148. https://doi.org/10.2307/3069429

Tondeur, J., Van Braak, J., & Valcke, M. (2007). Towards a typology of computer use in primary education. *Journal of Computer Assisted Learning*, *23*(3), 197–206. https://doi.org/10.1111/j.1365-2729.2006.00205.x

United Nations. (2015). *Resolution adopted by the General Assembly on 25 September 2015*. https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_RES_70_1_E.pdf

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2023). *Global education monitoring report: Technology in education: A tool on whose terms?* https://unesdoc.unesco.org/ark:/48223/pf0000385723

Wang, J., Tigelaar, D. E., Luo, J., & Admiraal, W. (2022). Teacher beliefs, classroom process quality, and student engagement in the smart classroom learning environment: A multilevel analysis. *Computers & Education*, *183*, 104501. https://doi.org/10.1016/j.compedu.2022.104501

Williams, D. N., & Gottfried, M. A. (2010). Who chooses the E in STEM? *Proceedings of Engineering Education*, *RDP 34*, 1–20.

Wu, X. (2003). Intrinsic motivation and young language learners: The impact of the classroom environment. *System*, *31*(4), 501–517. https://doi.org/10.1016/j.system.2003.04.001

Zheng, Y., & Chen, I. H. (2021). The relation between ICT usage and 15-year-old students' science self-efficacy. *International Journal of Information and Education Technology*, *11*(2), 88–95. https://doi.org/10.18178/ijiet.2021.11.2.1494

Received: *March 14, 2025* Revised: *August 31, 2025* Accepted: *September 05, 2025*

Cite as: Wu, W., & Park, K. H. (2025). The effects of science club activities on secondary school students' creative self-efficacy: Mediating quality education and moderating ICT usage. *Journal of Baltic Science Education*, *24*(5), 969–983. https://doi.org/10.33225/jbse/25.24.969

Weimiao Wu PhD Candidate, Department of Education, Faculty of Education, Woosuk University, 443, Samnye-ro, Samnye-eup, Wanju_gun, Jeonbuk-do, 55338, Republic of Korea. E-mail: alisamiao@stu.woosuk.ac.kr Website: https://www.woosuk.ac.kr ORCID: https://orcid.org/0009-0009-2282-9745

Kyung Hee Park *(Corresponding author)* PhD, Professor, Department of Education, Faculty of Education, Woosuk University, 443, Samnye-ro, Samnye-eup, Wanju_gun, Jeonbuk-do, 55338, Republic of Korea. E-mail: khpark@woosuk.ac.kr Website: https://www.woosuk.ac.kr ORCID: https://orcid.org/0000-0001-5949-666X